Perception of Virtual Multisensory Mobile Objects: Wandering around the Enactive Assumption

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Abstract

We explore here, through three complementary experiments on virtual objects, how intimate active relations with multisensory audio-visual and haptics perceptions allow to the cognitive creation of new believable and plausible objects than can be different of the virtual ones objectively implemented. The three experiments are based on "Pebble boxes" and consist in the exploration and the manipulation of multiple moving multisensory objects (the Pebbles). They show how an inferred scene is constructed from experience, as assumed in the cognitive Enactive concept, by means of three complementary strategies: "the Emergent Exploratory Procedures (EEP), the "Dynamic Manipulation Adaptivity" (DMA), the "Adaptive Experimental Learning" (AEL). It shows also the complementarity between the ergotic and the semiotic situation on the strategies to infer a believable and plausible scene.

I. Introduction

The work presented here is at the crossing point of (1) the perception of numerous mobile objects and (2) the perception of virtual objects or real objects altered by digital processing.

On the field of perception of numerosities, a wide quantity of works exist in the numbering of perceptual stimuli: numerosity judgments of visual stimuli, counting of acoustical stimuli and more recently, of unimodal tactile and bimodal tactile/visual stimuli [1] [2]. On the field of virtual reality, most of works aim at (performing comparative experiments in order to implement realistic virtual reality platforms or (2) perceptual multisensory cues in an easier way than using real physical materials. It is a very active field new results, mainly in hapto-visual coherencies.

However, new questions are risen by the existence of Virtual objects and their multisensory manipulation. Virtual objects – i.e. things for which the behaviors is computed by digital machines, sensorially transduced by digital/analog machines, are nevertheless "real objects" as they are really presented to our perceptions and acted by our actions, and are more and more used to perform tasks in the mechanico-optical world.

The question of the perception –and more generally the identification and the appraisal – of such "strange" real objects is then a full question, rarely asked directly. Within this general question, a less addressed one is that of perception of multiple moving objects from their multisensory behaviors, including haptic, visual and auditory feedbacks to actions. The work presented here concerns such issue of perception of virtual multiple moving multisensory objects. Three aspects have been previously explored in [3]:

(1) Estimation of the number of objects: subjects are asked to assess the number of objects inside a box

(2) Sensorial preferences: the subjects were presented with different feedback sounds and asked about believability and likeability

(3) sense of control: the subjects were asked to assess how much in control of the sound he/she felt.

We aim at exploring two questions directly tied to the concept of enaction and experimented in the context of virtual or computer transformed objects:

Type 1: What is the scene (or objects) inferred from the sensory experience, i.e. from the performed action and sensory feedbacks (auditory, visual, haptic)

Type 2: Are all the sensory modalities participating to the creation of the evoked scene, and, if not, what they are and why they are not?

The paper presents three successive experiments on three different pebble boxes, with the main observed results. It concludes by a comparison between each platform under the scopes of the enactive paradigm and the ergotic / non-ergotic properties of the situation [4].

The experiments on the three platforms are performed by 10 subjects: 25 to 55 years old, 4 females and 6 males, 6 non professional musicians and 4 musicians. One of them is a native blind people.

II. Experiments on "Pebble Box 1"

II.1. Description of the platform and of the experiments

In this platform designed by [5], a real pebble box is used as a tangible interface to control synthetic sounds. The sounds produced by the real pebble collisions are picked up by a microphone and analyzed by a specific software to extract "sounds grains" events. Sound

grains are used to control and trigger recorded synthesized sounds as: Bird songs, Water sounds , Crunching apple sounds, Sandpaper, …

Subjects are invited to manipulate the pebbles, freely. Three situations have been proposed with three different sounds : Birds songs, Water sounds, Crunching apple sounds. The questions were:

Q1.1. What are the scenes suggested to you?

Q1.2. Does the association of the sound and the manipulation believable, (categorized in 3 levels)?

II.2. Results

Objectively, the situations are paradoxical in the sense the palming pebbles produce sounds that are not pebble sounds.

(1) The inferred scene

In the three cases, with all the persons, an inferred - constructed - scene, that can be different from the objective one, is constructed from experience. Here are some examples extracted from subjects comments:

Birds songs

People imagine "walking on a gravel path or throwing a stone, triggering panic on birds in bushes.

Water sounds

People imagine "handling stone(s) in Water or disturbing animals (fishes) which escape".

Crunching apple sounds

People imagine "an animal within the box" and become anxious.

(2) Emergent Exploration Procedures:

The inference of a possible scene is a dynamic evolving process, in which people alternates scene assumption and exploration of ways of manipulation in order to converge to a believable inferred scene, through what we call "Emergent Exploratory procedures (EEP). For example:

When Birds songs

Gesture to walk with hands

When Water sounds

Gesture to throw pebbles in water,

Gesture of « swimming with hands »

Crunching apple sounds

Gesture to crunch something with hands,

Gesture to scratch a box in which is an animal

Prudent gestures when supposed animals or unknown living organisms nested somewhere.

(3) Believability:

First, as observed in [3], the situation when subjects hear "sound water" is the most believable. But the main non expected surprising observation, from the observers and from the subjects, done in such type of experiment, when the exploration is free , and when analyzing spontaneous and free comments, is that there are no inferred scenes that could be totally un - believable. Even in the cases looking very far than a real situation (such as the bird or the apple crunching sounds), subjects are likely surprised, but « nicely surprised » (See photograph in Figure 2. The situation did not seem to them completely impossible. They modify their manipulation and their interpretation to make as best as possible the situation believable.

Figure 2. Left : "Pebble Box 1"
Right : An experiment: "surprising but believable";

III. Experiments on "Pebble Box 2"

II.1. Description of the platform and of the experiments

The platform is the same that used in [6]. People handle 10 physically-based 3D cubes or spheres, simulated by the Open Dynamics Engine software in squared box (Figure 3). They stir up by means of a Phantom Omni device. Sounds of collisions are triggered by collision detection algorithm. There are different possibilities for the visualization:

- The ten objects are visually represented or not
- The manipulator is visible or not
- Pebbles could be cubes or spheres.
- Visual size can be different to haptic size.

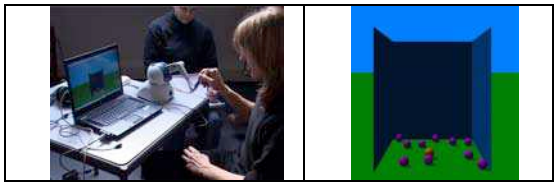

Figure 3. Pebble Box 2: VR Haptic manipulation & "Changing the visualization"

III.2. Results

Globally, and similarly than in Pebble Box 1, people try to infer a believable scene, if possible from all the multisensory feedbacks. But differently than in Pebble Box 1, and if they cannot, they are led to elude some modalities, the eluded sensory feedback being not always the same for all the experiments.

(1) When no visualization, people trend to infer a phenomenon rather than « clearly cut objects », (for example "pebbles"). For example

- In addition to clearly cut objects feeling, people talk about « force field », « magnetic field », paste, medium resistance, grain in paste, etc…

- When visual objects are smaller than their physical radius, the physical inferred objects are supposed surrounded by a transparent shell or extended by a force field.

(2) Subjects change the way they manipulate when they have visual perception of themselves. We observe here the processes of Emergent Exploratory procedures (EEP). For example:

- *They explore the whole space more when they have visual feedback of themselves than without*
- *They attempt to create the conditions allowing them to explore the shape of the supposed objects.*

IV. Experiments on "Pebble Box 3"

IV.1. Description of the platform and of the experiments

The Pebble box 3 is a 2D Virtual Pebble Box composed of a circular box containing 8 mobile masses more or less rigid, in interaction of collisions more or less visco-elastic and with 1 more or less rigid mass (the manipulator) controlled by the ERGOS haptic high quality device.

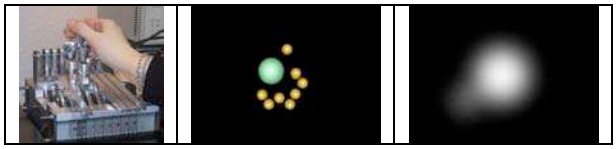

Figure 5. Pebble Box 2: "Changing the matter & the visualization" & VR Haptic manipulation

By changing the physical parameters of the interactions between each pairs of pebble-masses and also between each pebble-mass and the haptic stick-mass, we modeled the matter changing. Following a first serie of experiences done [7], four well-categorized cases have been chosen:

	1	2	3	4
Pebbles Rigidity	high	low	high	high
Stick-pebble rigidity	high	low	high	high
Viscosity	medium	medium	Low	Low
Pebble size	Big	medium	medium	small

Two visualizations were used: (1) a ball like visualization; (2) a blurred medium-like visualization

The sounds are the sounds produced by the simulation of the pebbles at acoustical frame rate (44KHz). When colliding, the two pebbles are vibrating producing one sound each, as in the real mechanical world. The sound signals depend on the physics of the collision (matter of the colliding objects, strength of the hit, velocities, etc.). This simulation is objectively a very realistic physical simulation of identical pebbles pushed with another object.

IV.2. Results

Similarly than in Pebble Box 2, people try to infer a believable scene, if possible from all the multisensory feedbacks, and if not, they are led to elude some sensory feedbacks. As previously, the inferred scene is not necessarily coherent with the objective simulated one, confirming here too a creation of a plausible scene from the sensori-motor experience.

(1) The value of physical material interactions leads to infer two types of different categories of scene not necessarily similar to the objective one. For example:

- *People feel a kind of « medium », « paste, « force field », « cotton », etc. when grains are in soft colliding interactions*
- *People feel clearly-cut objects but not necessary all of them or of the same size.*
- *When the sound or the vision are not consistent, they are preferably eluded.*

(2) The dynamic of the coupling of the manipulation, mainly the intensity of grasping done by the performer depends of the implemented scene. People adapt his own dynamic and the dynamic of coupling to the physical constitution of the manipulate object. We are confronted here to a kind of Dynamic Manipulation Adaptivity (DMA). For example:

- *When objects are in a strong rigid interaction, people grasp strongly the device and act (presses, moves) with high energy.*
- *When objects are in soft elastic interaction, or when they are small, people manipulate delicately for example by grasping the stick with fingers.*

(3) The refinement of the exploration increases along the experience and the scene inferred change progressively. We are confronted here to a a kind of Adaptive Experimental Learning (AEL). For example:

- *When the simulated matter is very soft, people start with feeling nothing and progressively tend to feel a type of « resistant or viscous » field, or field+lumps*
- *When the simulated matter is Very rigid and the objects very big, without visualization, People start with feeling « one big object », explore its shape and progressively discover eventually the others, that are imagined smaller.*

V. Comparison

V.1. Enactive experience

In all the experiments, with all the subjects, an inferred scene is constructed from the sensori-motor experience. This inferred (constructed) scene can be different from the objective scene. We can talk about "a created scene". There is more a cognitive creation of objects than an identification of objects.

Using Virtual objects to explore how objects as cognitive categories emerge, we can say that these observations, in a free experimental context, fall on the scope of the enactive paradigm: *"...cognition is not the representation of a pregiven world by a pregiven mind but is rather the enactment of a world and a mind on the basis of a history of the variety of actions that a being in the world performs."* [8].

During the process of inference of a plausible scene, subjects developed three complementary strategies:

• Emergent Exploratory Procedures (EEP) in which subjects are seeking for on-line exploratory procedures in concordance with assumption on the possible scene suggested by actions and sensory feedbacks.

• Dynamic Manipulation Adaptivity (DMA) in which the subjects adapt very quickly and "on the fly" his manual dynamic performance to the sensory feedbacks and the supposed felt objects.

• Adaptive Experimental Learning (AEL): We observe that subjects learn very quickly, dynamically and "on the fly", what are the best manipulations. This is a derivative property of intimacy and embodiment: subjects are "with" the object.

V.2. Ergotic / non-ergotic interactions

One of the reason for which we performed the experiments on the three "Pebble Boxes" is their complementarity regarding the physical consistency between gestures and sensory feedbacks. An efficient typology for that is the typology introduced by Cadoz [4], who distinguishes ergotic situations, and non – ergotic ones, i.e. purely epistemic and/or semiotic. In ergotic situations, there is a physical energetic coherence from action to the sound and the image that are so produced. This property is a fundamental property to support intimacy and embodiment [4]. In non ergotic interactive situations, such as the mouse – visual one, sign language, musical conductor control, etc., the information exchanged are purely semiotic and epistemic. We noticed that:

• In pebble box 1, the relation between the gestures and the auditory sensory feedback is purely semiotic / epistemic.

• In pebble box 2, the relation between action and visual feedback is totally managed by physical modeling and so it is an ergotic relation. Conversely the sounds are triggered from a signal event and consequently, it is a non-ergotic situation.

• In pebble box 3, the relation between action and all the visual feedbacks (visual and auditory) is totally managed by physical modeling and so it is a multisensory ergotic relation.

Two remarkable observations can be extracted from the performances:

1. More the situation is ergotic, more are the effects of dynamic adaptation and dynamic on-line learning. Less are believability of the whole situation, in the sense that some modalities are sometimes eluded to conclude to a plausible effect. This is very noticeable in pebble box 3.
2. Less the situation is ergotic, more are the importance of the emergent exploratory procedures and the metaphoric prospect. In addition, most of the scenes are believable in accordance of the whole sensory returns.

VI. Conclusions

We conducted here observations in order to go initiate new research on what could be the perception of virtual objects, assuming that virtual objects have also to be considered as real objects, while they can be explored sensorially in a stable context. Such researches will be complementary to others aiming at whether using virtual objects as versatile experimental settings to go forward in the understanding of the human perception or using virtual reality platforms for training.

Differently than in these others experiments, usually based on very precise questions (subjective or quantitative), the exploration we propose to the subjects are totally free, as if they were in front a really new object he / she is discovering. We can see that Virtual Reality could be "a laboratory to capture how human construct what an object is". Thus, the method is to analyze "natural human behaviors and spontaneous and free comments", when they are discovering through their action and perception, without any other preliminary comments form the experimenter, such "strange new things".

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